US009225214B2

(12) **United States Patent**
Tanimoto

(10) **Patent No.: US 9,225,214 B2**
(45) **Date of Patent: Dec. 29, 2015**

(54) **DISK MOTOR AND ELECTRIC WORKING MACHINE INCLUDING THE SAME**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 130 days.

(21) Appl. No.: **13/596,927**

(22) Filed: **Aug. 28, 2012**

(65) **Prior Publication Data**

US 2013/0076192 A1 Mar. 28, 2013

(30) **Foreign Application Priority Data**

Sep. 28, 2011 (JP) 2011-213308

(51) **Int. Cl.**
H02K 3/26 (2006.01)
H02K 23/54 (2006.01)
H02K 13/00 (2006.01)

(52) **U.S. Cl.**
CPC ***H02K 3/26*** (2013.01); ***H02K 23/54*** (2013.01); *H02K 13/006* (2013.01)

(58) **Field of Classification Search**
CPC H02K 27/12; H02K 27/20; H02K 3/28; H02K 3/12
USPC 310/173, 180, 208, 224, 228, 237
See application file for complete search history.

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(57) **ABSTRACT**

A disk motor including: a rotor including, a commutator disk including a commutator pattern, and at least one coil disk including a coil pattern; a stator including a magnetic flux generating part opposed to the coil pattern of the coil disk; an electric current supply part configured to supply electric current to the coil pattern via the commutator disk and, an output shaft configured to be rotated by a rotational force of the rotor, wherein a radiating pattern is provided to an outer periphery side of the commutator pattern of the commutator disk.

14 Claims, 8 Drawing Sheets

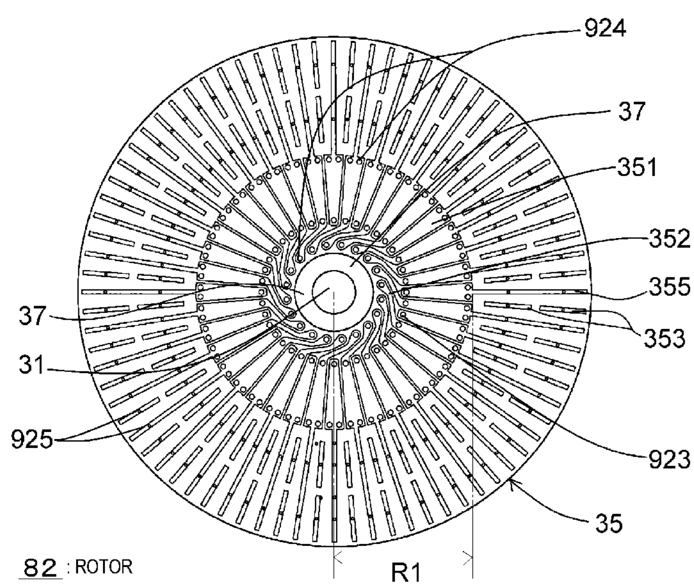


FIG. 1

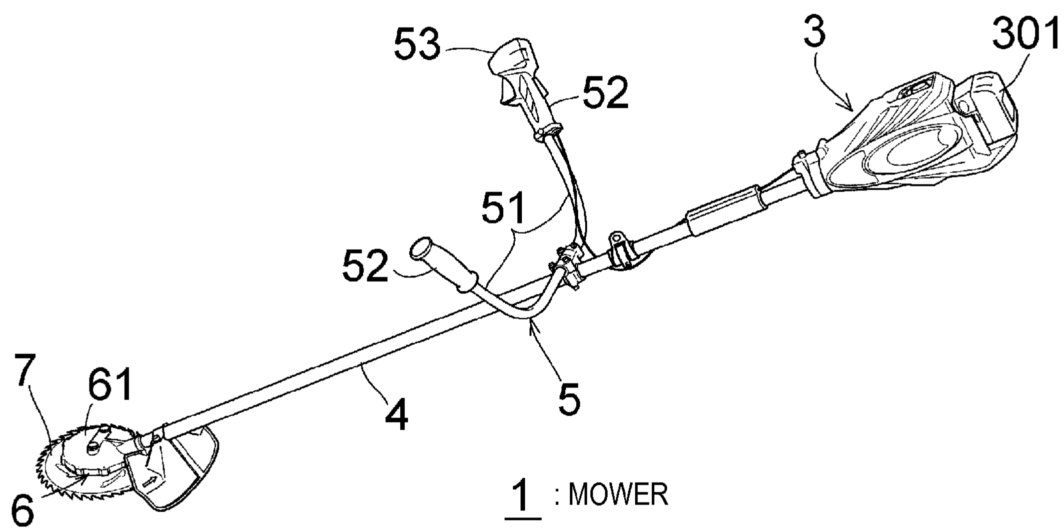


FIG. 2

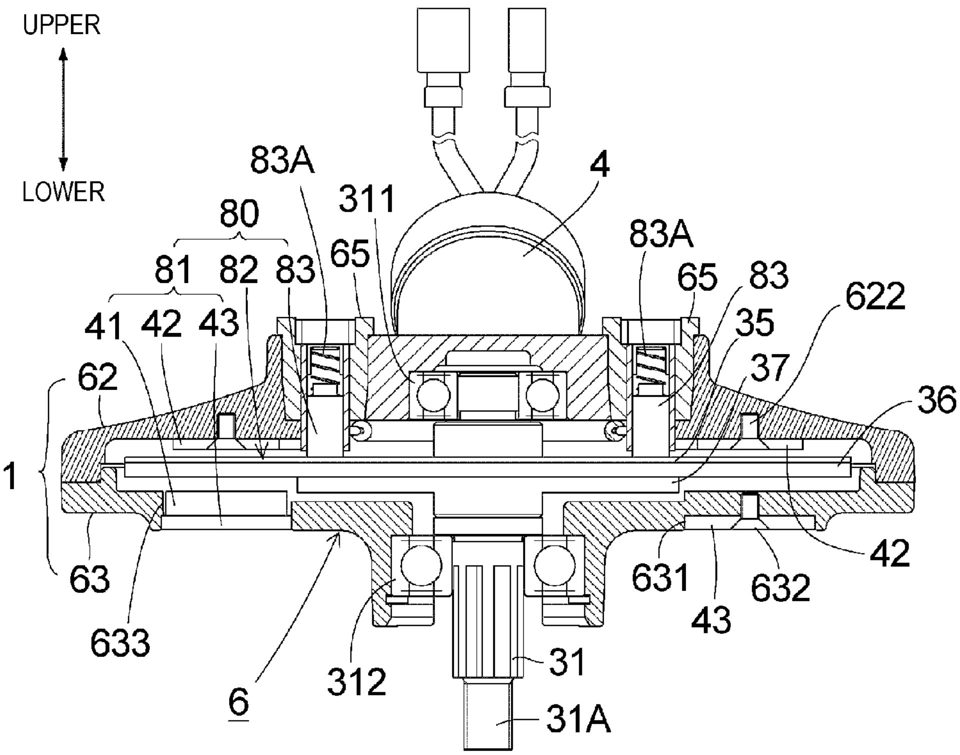

UPPER
LOWER
83A
4
311
80
83A
81
82
83
65
65
83
622
41
42
43
35
62
37
36
61
42
63
631
632
43
633
312
31
6
31A

FIG. 3

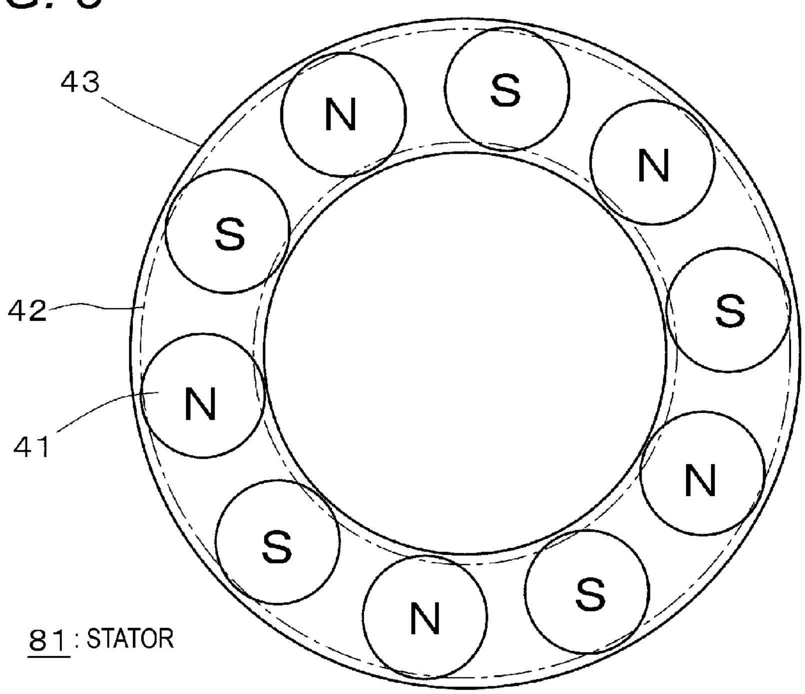

43
N
S
N
S
S
42
N
41
N
S
S
N
81: STATOR

FIG. 4

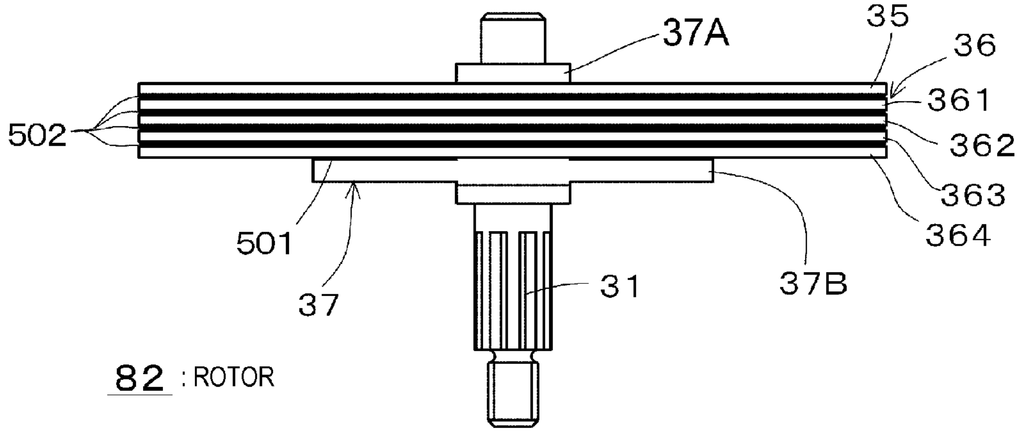

37A
35
36
361
362
363
364
502
501
37
31
37B
82 : ROTOR

FIG. 5

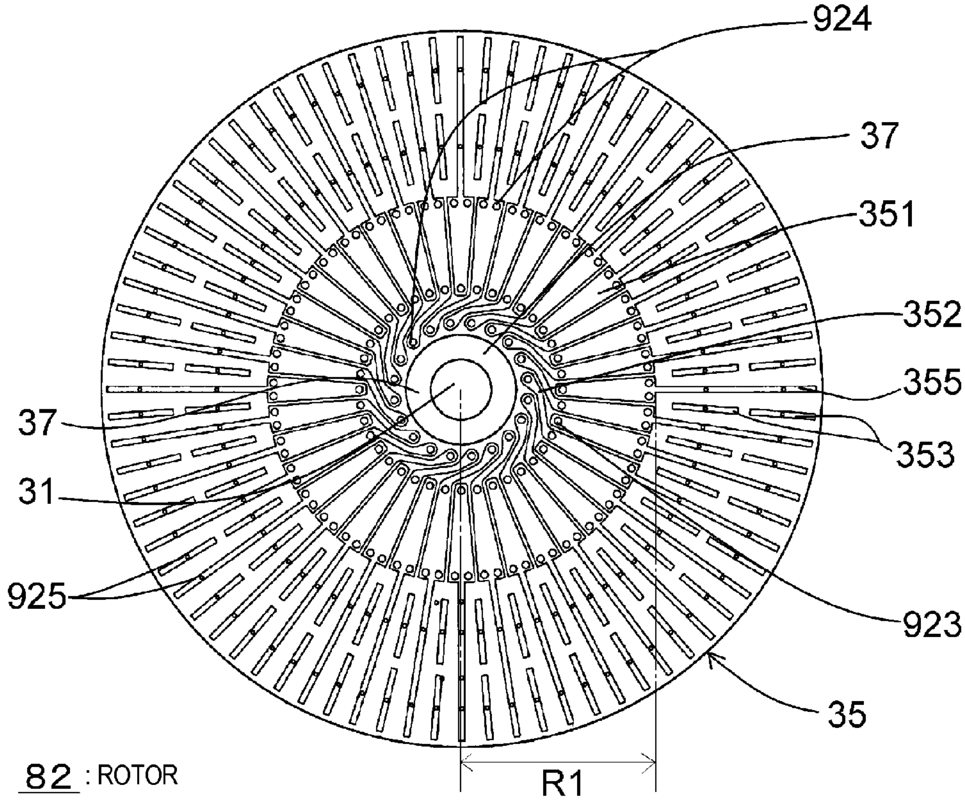

924
37
351
352
355
353
37
31
925
923
35
R1
82 : ROTOR

FIG. 6

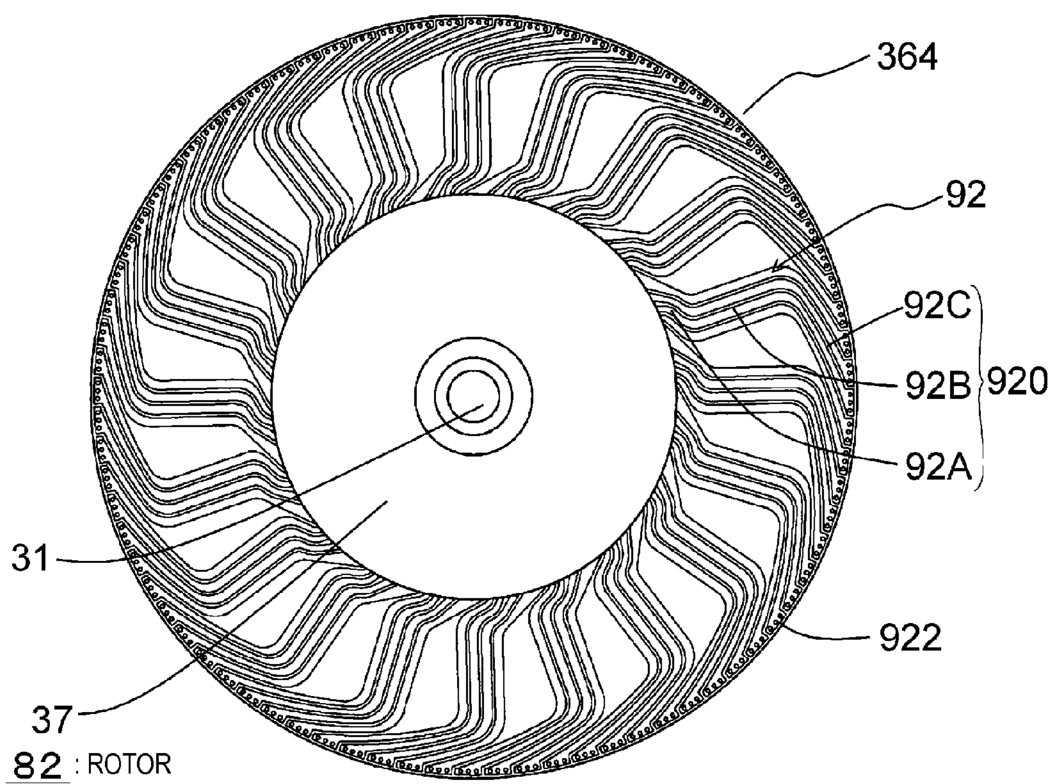


FIG. 7

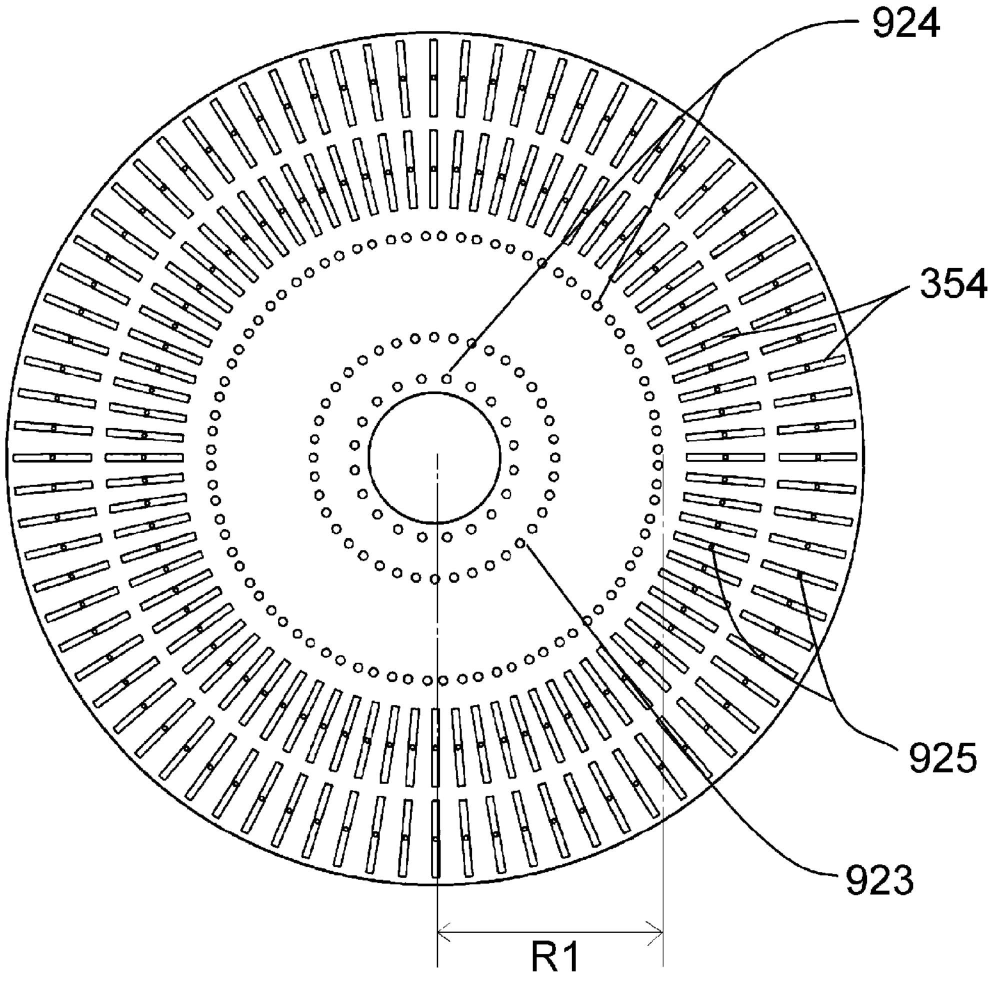


FIG. 8A

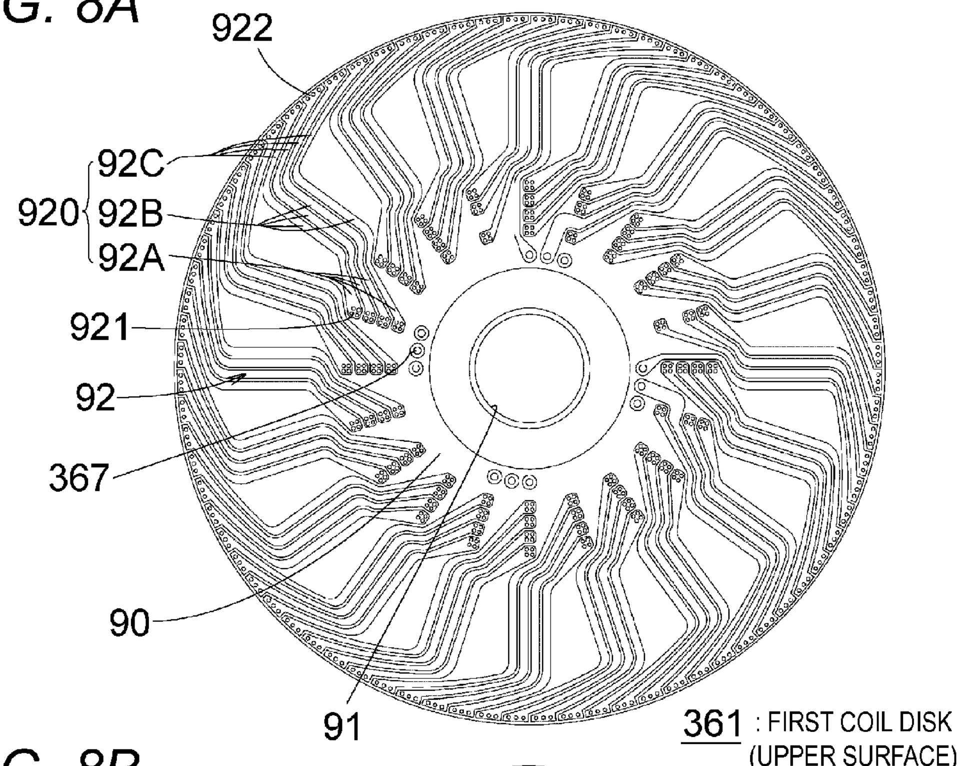

922
920
92C
92B
92A
921
92
367
90
91
361 : FIRST COIL DISK
(UPPER SURFACE)

FIG. 8B

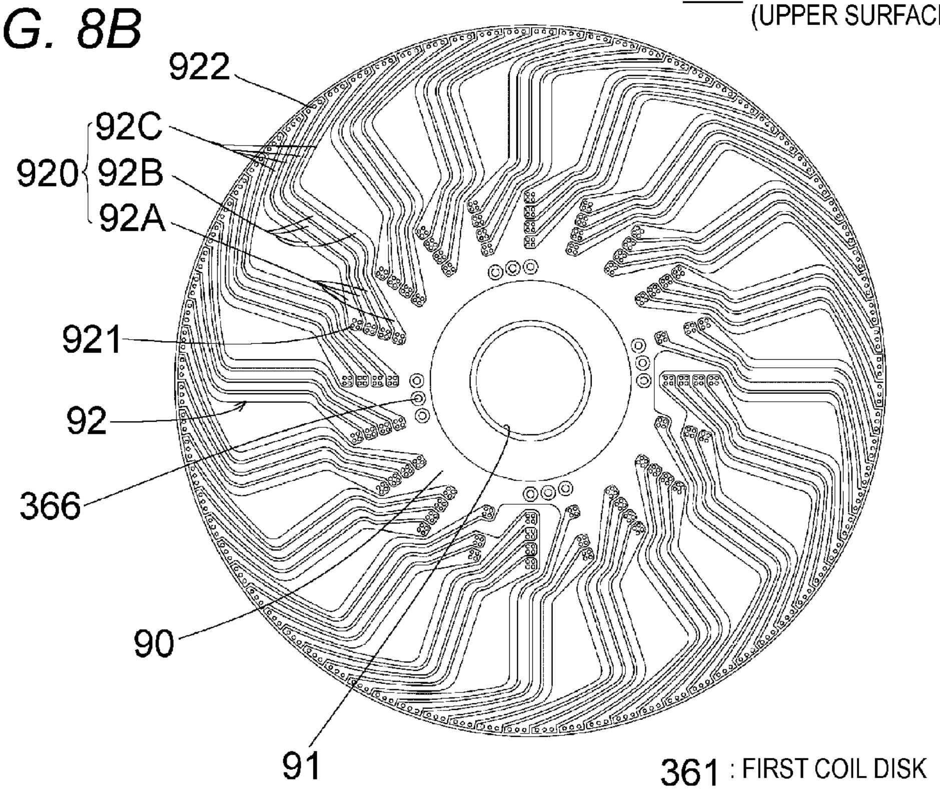
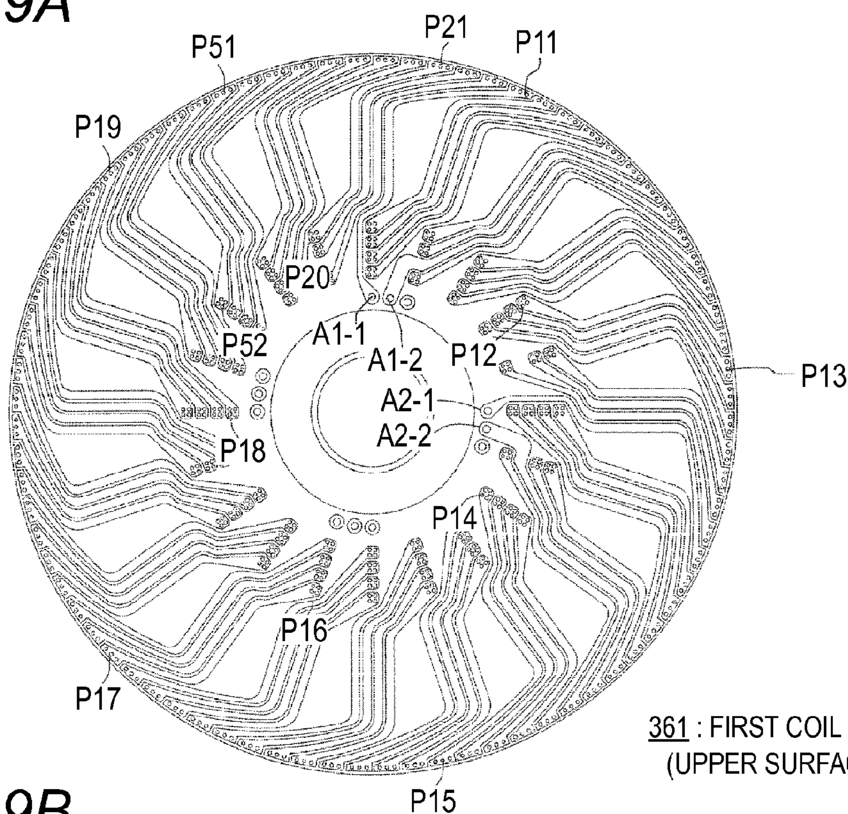
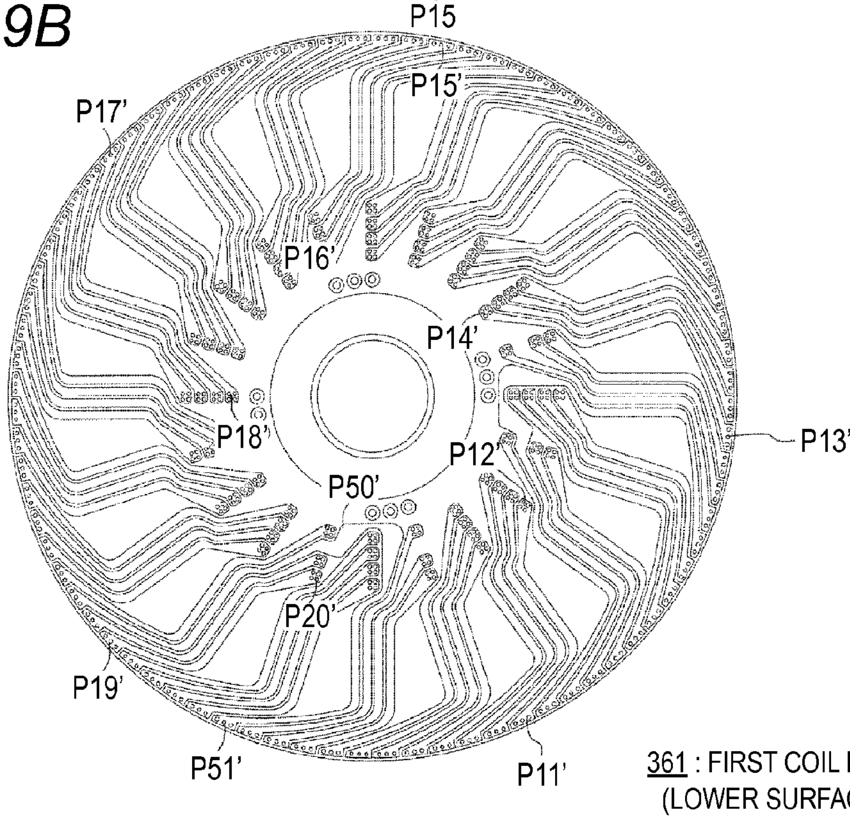

922
920
92C
92B
92A
921
92
366
90
91
361 : FIRST COIL DISK
(LOWER SURFACE)

FIG. 9A



361 : FIRST COIL DISK
(UPPER SURFACE)

FIG. 9B



361 : FIRST COIL DISK
(LOWER SURFACE)

FIG. 10

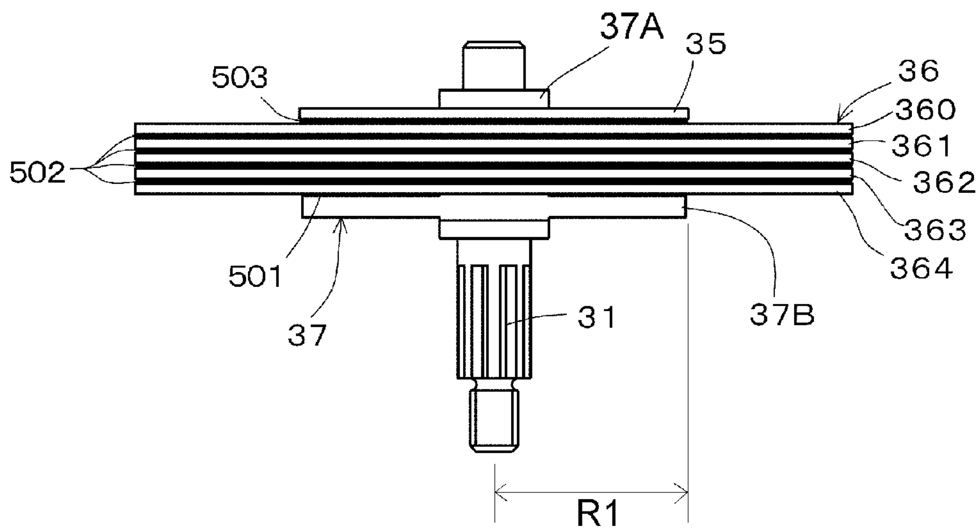
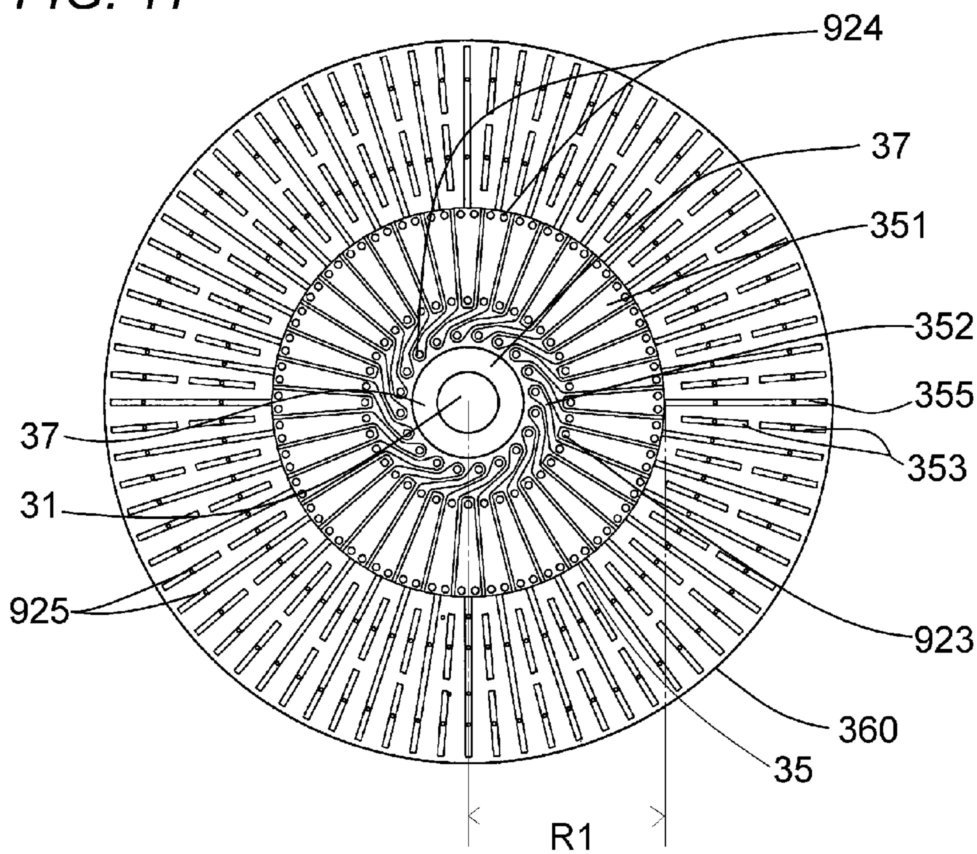

37A
35
503
36
360
361
502
362
363
501
364
31
37
37B
R1

FIG. 11


924
37
351
352
355
37
353
31
925
923
360
35
R1

DISK MOTOR AND ELECTRIC WORKING MACHINE INCLUDING THE SAME

CROSS-REFERENCE TO RELATED APPLICATIONS

This application claims priority from Japanese Patent Application No. 2011-213308 filed on Sep. 28, 2011, the entire contents of which are incorporated herein by reference.

TECHNICAL FIELD

Aspects of the present invention relate to a disk motor including a coil disk and a commutator disk to rotationally drive an output shaft thereof and an electric working machine including the same.

BACKGROUND

A related-art disk motor includes an output shaft, an approximately disk-shaped coil disk fixed to the output shaft and printed with a coil pattern, a commutator disk having a commutator pattern connected to the coil pattern, a magnet disposed to face the coil pattern and a brush for applying electric current to the commutator pattern (see, Japanese Patent No. 3636700).

A rotational number of the disk motor is determined in accordance with a voltage supplied from the brush, an electric current of the disk motor, a coil pattern of the coil disk, a magnetic flux of the magnet and a number of the brushes (number of poles). When the voltage supplied from the brush and the electric current of the disk motor are constant, it is possible to set the rotational number of the disk motor at a desired rotational number by changing the coil pattern of the coil disk, the magnetic flux of the magnet and the number of the brushes.

JP-A-2004-80996 is not directed to a disk motor but to a technology for improving a cooling and radiating performance of a stator coil in a commutator motor by increasing the cooling and radiating surface area of the stator coil.

SUMMARY

In order to achieve a high output power in a disk motor, it is necessary to increase electric current supplied to the coil pattern. However, when a large electric current flows in the commutator pattern, heating of the commutator disk due to electrical resistance becomes a problem. As a countermeasure for such a heating problem, there is no proper disclosure in either of Japanese Patent No. 3636700 and JP-A-2004-80996. The technology of JP-A-2004-80996 relates to a cooling of a coil in a configuration that winding is arranged around a core and is not suitable for radiation of a coil disk having a coil pattern.

Aspects of the present invention has been made to solve the above-described problems and an object of the present invention is to provide a disk motor having an improved radiation performance as compared to related-art and an electric working machine including such a disk motor.

According to an aspect of the invention, there is provided a disk motor including: a rotor including, a commutator disk including a commutator pattern, and at least one coil disk including a coil pattern; a stator including a magnetic flux generating part opposed to the coil pattern of the coil disk; an electric current supply part configured to supply electric current to the coil pattern via the commutator disk and, an output shaft configured to be rotated by a rotational force of the rotor,

wherein a radiating pattern is provided to an outer periphery side of the commutator pattern of the commutator disk.

The radiating pattern may be provided on the commutator disk.

The radiating pattern may be provided on at least a surface of the commutator disk that contacts with the electric current supply part.

The radiating pattern may be provided on both surfaces of the commutator disk, and the radiating patterns on both surfaces may be connected to each other by a thermal conductive material penetrating through the commutator disk.

The commutator disk and the coil disk may have substantially the same outer diameter.

The radiating pattern may be provided at a position in a radial direction that faces the magnetic flux generating part.

The radiating pattern may be divided into a plurality of segments in at least one of a radial direction and a circumferential direction.

The radiating pattern and the commutator pattern may be made of the same material.

The radiating pattern may include an extended radiating pattern which extends from the commutator pattern.

The commutator pattern may be divided into a plurality of segments, and the extended radiating pattern does not short-circuit between different segments of the commutator pattern.

The radiating pattern may include an insulated radiating pattern which is insulated from the commutator pattern.

According to another aspect of the invention, there is provided an electric working machine including the above-described disk motor.

Any combinations of the above components and a modification thereof are also effective as an aspect of the present invention.

According to aspects of the present invention, since the radiating pattern is provided to an outer periphery side of the commutator pattern of the commutator disk, it is possible to realize a disk motor having an improved radiation performance as compared to related art. Further, it is possible to realize an electric working machine including such a disk motor.

BRIEF DESCRIPTION OF DRAWINGS

FIG. **1** is a perspective view illustrating a mower **1** according to a first embodiment of the present invention;

FIG. **2** is a front cross-sectional view illustrating a driving part **6** of the mower **1** illustrated in FIG. **1**;

FIG. **3** is a schematic plan view illustrating a stator **81** illustrated in FIG. **2**;

FIG. **4** is a front view illustrating a rotor **82** illustrated in FIG. **2**;

FIG. **5** is a plan view illustrating the rotor **82** illustrated in FIG. **2**;

FIG. **6** is a bottom view illustrating the rotor **82** illustrated in FIG. **2**;

FIG. **7** is a bottom view illustrating a commutator disk **35** illustrated in FIG. **4**;

FIG. **8**A is a plan view illustrating a first coil disk **361** illustrated in FIG. **4** and FIG. **8**B is a bottom view illustrating the first coil disk **361**;

FIG. **9** (**9**A, **9**B) is a view explaining a coil pattern of the first coil disk **361**;

FIG. **10** is a front view illustrating a rotor according to a modified embodiment; and

FIG. **11** is a plan view illustrating a rotor according to the modified embodiment.

DETAILED DESCRIPTION

Hereinafter, a preferred embodiment of the present invention will be described by referring to the accompanying drawings. The same or similar reference numerals are applied to the same or similar parts and elements throughout the drawings, and the duplicated description thereof will be omitted. Further, the embodiment is illustrative and is not intended to limit the present invention. It should be noted that all the features and their combinations described in the embodiment are not necessarily considered as an essential part of the present invention.

FIG. **1** is a perspective view illustrating a mower **1** according to an embodiment of the present invention. The mower **1** as an example of an electric working machine. The mower **1** includes a power supply part **3**, a pipe part **4**, a handle part **5**, a driving part **6** and a cutting blade **7**.

The power supply part **3** includes a removable battery **301** as a power supply. The pipe part **4** mechanically connects the power supply part **3** and the driving part **6**. Further, wirings (not-illustrated) electrically connecting the power supply part **3** and the driving part **6** are inserted in the inside of the pipe part **4**. Power is supplied from the power supply part **3** to the driving part **6** via the wirings. The driving part **6** includes a head housing **61** in which a disk motor is accommodated. The driving part **6** is configured to rotationally drive the cutting blade by the power supplied from the power supply part **3**. The configuration of the disk motor will be described later.

The handle part **5** is fixedly attached to the middle of the pipe part **4**, i.e., between the power supply part **3** and the driving part **6**. The handle part **5** is configured by mounting a grip **52** on leading ends of a pair of arms **51**, respectively. One grip **52** is provided with a throttle **53**. As an operator operates the throttle **53**, it is possible to adjust the power supplied to the driving part **6**. That is, it is possible to adjust a rotational number of the cutting blade **7**. The cutting blade **7** is formed in an approximately disk shape and provided at its peripheral edge with serrations. Further, the cutting blade is provided at its central portion with a hole (not-illustrated). The hole is mounted on an output shaft of the disk motor (will be described later).

FIG. **2** is a front cross-sectional view illustrating the driving part **6** of the mower **1** illustrated in FIG. **1**. As illustrated in FIG. **2**, the extending direction of an output shaft **31** is defined as a vertical direction. The driving part **6** includes a disk motor **80** which is accommodated in a case **61**. The case **61** is made of metal, for example, aluminum. The case **61** is configured by integrally fitting a cover part **62** and a base part **63**. The disk motor **80** includes a stator **81**, a rotor **82** and a pair of brushes **83**. The pair of brushes **83** are symmetrically provided with respect to a rotational shaft (output shaft **31**) of the disk motor **80** and supported on a brush holder **65** of the cover part **62**. Each brush **83** is urged (downward) toward a commutator disk **35** (to be described later) by a spring **83**A so that a lower surface thereof contacts a commutator pattern made of conductor such as a copper on the commutator disk **35**. The brush **83** is connected to the power supply part **3** of FIG. **1** and serves as an electric current supply part to supply electric current to a coil pattern (to be described later) of the rotor **82**.

The stator **81** includes a magnet **41** as a magnetic flux generating part, an upper yoke **42** and a lower yoke **43**. The upper yoke **42** and the lower yoke **43** are made of soft magnetic material. The upper yoke **42** is formed in a ring shape and fixed to a lower surface of the cover part **62** by a screw **622**, for example. The lower yoke **43** is formed in a ring shape which has a diameter substantially the same as a diameter of the upper yoke **42**. The lower yoke **43** is fixed into a ring-shaped groove **631** formed on a lower surface of the base part **63** by a screw **632**, for example. The magnet **41** is fixedly fitted into a hole part **633** which is formed on an upper surface of the base part **63**.

FIG. **3** is a schematic plan view illustrating the stator **81** illustrated in FIG. **2**. As illustrated in FIG. **3**, the magnets **41** are formed into a disk shape, for example. Further, a plurality of (for example, ten) magnets **41** are disposed side by side in an equiangular pitch on a circumference of the stator. In addition, the same number of the hole parts **633** of FIG. **2** accommodating the magnets **41** are placed side by side on a circumference thereof. The center of the circumference is substantially coincident with a rotation center of the disk motor **80**. Magnetic poles of upper surfaces in adjacent magnets **41** are different from each other. Although a rare earth magnet such as a neodymium magnet can be desirably used as the magnet **41**, a sintered magnet such as a ferrite magnet may also be used. The upper yoke **42** and the lower yoke **43** are intended to increase the magnetic flux density applied to the coil pattern of the rotor **82** (to be described later).

As illustrated in FIG. **2**, the rotor **82** includes the output shaft **31** (rotor shaft), a commutator disk **35**, a coil part **36** (laminate of coil disks) and a supporting member **37**. The output shaft **31** is rotatably supported by an upper bearing **311** fixed to the cover part **62** and a lower bearing **312** fixed to the base part **63**. A male screw **31**A is formed on a lower side end of the output shaft **31** and the cutting blade **7** of FIG. **1** is fixed to the male screw **31**A by a fastener (not-illustrated). The upper surface of the commutator disk **35** is a contact surface (sliding surface) with the brush **83**. Electric current is supplied from the power supply part **3** illustrated in FIG. **1** to the coil part **36** via the brush **83** and the commutator disk **35**.

FIG. **4** is a front view illustrating the rotor **82** illustrated in FIG. **2**, FIG. **5** is a plan view thereof and FIG. **6** is a bottom view thereof.

As illustrated in FIG. **4**, the coil part **36** includes a first coil disk **361** to a fourth coil disk **364**. The commutator disk **35** and the first coil disk **361** to the fourth coil disk **364** are laminated to form a set of rotor board while sandwiching a sheet-like (insulation) adhesive layer **502** therebetween, respectively. The sheet-like adhesive layer **502** has the same shape as each coil disk as viewed in an axial direction and covers substantially the entire surface of each coil disk.

Each of the first coil disk **361** to the fourth coil disk **364** is configured so that a coil pattern (will be described later) is formed on both sides of an insulating resin board (for example, a glass fiber reinforced epoxy resin board). The commutator disk **35** is configured so that a commutator pattern and a radiating pattern (both to be described later) are formed on an insulating resin board (for example, a glass fiber reinforced epoxy resin board) of which diameter is substantially equal to that of each coil disk. The commutator disk **35** is fixedly adhered to an upper surface (upper surface of the first coil disk **361**) of the coil part **36**.

The supporting member **37** is made of, for example, resin such as nylon and is coaxially fixed to the output shaft **31**. The supporting member **37** includes a cylinder part **37**A formed in a substantially cylindrical shape and a boss **37**B (flange) formed in a substantially disk shape. The boss **37**B has a diameter smaller than that of each coil disk and is projected outward from the side of the cylinder part **37**A in a vertical direction relative to the output shaft **31**. The set of rotor board is placed on an upper surface of the boss **37**B via a sheet-like adhesive layer **501** (or adhesive such as epoxy adhesive). Here, the sheet-like adhesive layer **501** has the same shape as the boss **37**B, as seen in an axial direction. And then, the commutator disk **35**, the coil part **36** and the boss **37**B are subjected to a hot press (pressed in a lamination direction in a heated state) and thus integrally adhered in a laminated state.

As illustrated in FIG. **5**, a commutator pattern **351** is formed on the commutator disk **35** and is radially divided into 40 segments. Segments of predetermined positions are connected to each other. For example, two segments (the first segment and the ninth segment, or the second segment and the tenth segment, etc.) between which seven segments are interposed are connected to each other by a connection pattern (not-illustrated) which is formed on a surface opposite to a connection pattern **352** formed inside. The connection pattern may be formed on the coil disk. A commutator pattern **351** of the commutator disk **35** and a coil pattern of at least one of the first coil disk **361** to the fourth coil disk **364** are electrically connected to each other by a through-hole **923**.

The commutator pattern **351** is provided in a circular region within a radius R**1** from the center on the commutator disk **35**. Meanwhile, an insulated radiating pattern **353** and an extended radiating pattern **355** as a radiating pattern are provided in a region outside of the circular region, that is, a ring-shaped region on the commutator disk **35** other than the circular region. The ring-shaped region is a region facing the magnet **41** (magnetic flux generating part) of the stator **81** illustrated in FIGS. **2** and **3**.

Both the insulated radiating pattern **353** and the extended radiating pattern **355** extend in a radial direction of the commutator disk **35**. The commutator pattern **351**, the insulated radiating pattern **353** and the extended radiating pattern **355** are made of a conductive material such as copper. Preferably, these patterns are made of the same material and formed by the same etching process. The commutator pattern **351**, the insulated radiating pattern **353** and the extended radiating pattern **355** have substantially the same height from a board surface of the commutator disk **35**.

The insulated radiating pattern **353** is insulated from the commutator pattern **351** and the extended radiating pattern **355** extends from the commutator pattern **351**. The insulated radiating pattern **353** is divided into a plurality of segments in both a radial direction and a circumferential direction of the commutator disk **35**. In an example of FIG. **5**, the insulated radiating pattern is divided into 2 segments in the radial direction and 40 segments in the circumferential direction. The extended radiating pattern **355** is divided into 40 segments in a circumferential direction of the commutator disk **35**. Each of the insulated radiating patterns **353** and the extended radiating patterns **355** has a width in a circumferential direction smaller than each segment of the commutator pattern **351**. Each of the extended radiating patterns **355** extends from only one segment of the commutator pattern **351** and does not bridge (short-circuit) between different segments of the commutator pattern **351**. At this time, since the extended radiating pattern **355** is not only narrow in width but also becomes a dead-end of a current path, the extended radiating pattern is configured such that an electrical resistance is high and an electric current does not flow (or flow only a little) therein.

As illustrated in FIG. **6**, the fourth coil disk **364** includes a coil pattern **92** (other coils also have coil pattern). The coil pattern **92** will be described later by referring to FIGS. **8** and **9**.

FIG. **7** is a bottom view illustrating a commutator disk **35** (a view illustrating a surface opposing the first coil disk **361**). An insulated radiating pattern **354** as a radiating pattern is provided at an outside of a circular region within a radius R**1** from a center in a bottom side of the commutator disk **35**, that is, a ring-shaped region other than the circular region. The insulated radiating pattern **354** is divided into a plurality of segments in both a radial direction and a circumferential direction of the commutator disk **35**. A connection pattern is provided in a circular region within a radius R**1** from a center in a bottom side of the commutator disk **35** and connects between the segments of the commutator pattern **351** illustrated in FIG. **5**. However, illustration of the connection pattern is omitted.

The insulated radiating pattern **353** and the extended radiating pattern **355** (surface side radiating pattern) illustrated in FIG. **5** and the insulated radiating pattern **354** (backside radiating pattern) illustrated in FIG. **7** are connected (coupled) to each other by a radiating through-hole **925**, respectively. A high thermal conductivity material such as copper is plated in an inner surface of the radiating through-hole **925**. Alternatively, a high thermal conductivity material such as copper may be embedded into an inner side of the radiating through-hole **925**.

The shape of the coil pattern is not particularly limited but a suitable example thereof will be described. FIG. **8**A is a plan view illustrating a first coil disk **361** illustrated in FIG. **4** and FIG. **8**B is a bottom view illustrating the first coil disk **361**. Since the other coil disks have the same configuration and pattern as the first coil disk **361**, only the first coil disk **361** will be described herein.

The first coil disk **361** includes coil patterns **92** which are respectively provided on both surfaces of a disk-shaped insulating board **90**. The cylinder part **37**A of FIG. **5** is inserted into a through-hole **91** which is provided in the center of the insulating board **90**. A total of twelve through-holes **366** connecting between layers are formed in such a way that three through-holes **366** are provided at an interval of every 90° around the center of the insulating board **90**. A distance from each through-hole **366** to the center of the insulating board **90** is equal to each other. Each through-hole **366** is communicated with any one of the through-holes **923** which are formed on the commutator disk **35**.

The coil pattern **92** is made of a conductive material such as copper and formed by carrying out an etching process in a state where both surfaces of a disk-shaped insulation board **90** are laminated with a conductive material such as a copper foil and covered with a mask. The coil pattern **92** includes a group **920** of partial coil pattern composed by a pattern of four columns which are adjacent to each other and have substantially equal width. Twenty groups **920** of partial coil pattern are provided in both surfaces of the first coil disk, respectively. The group **920** of partial coil pattern is obtained by sequentially connecting a group **92**A of inside connection pattern, a group **92**B of radial pattern and a group **92**C of outside connection pattern. The groups **92**A of inside connection pattern on both surfaces are electrically connected to each other by a through-hole **921** which is formed in the vicinity of an end thereof. The groups **92**C of outside connection pattern on both surfaces are electrically connected to each other by a through-hole **922** which is formed in the vicinity of an end thereof. The group **92**B of radial pattern extends radially outward from a center side of the insulating board **90** and spans between the group **92**A of inside connection pattern and the group **92**C of outside connection pattern. The groups **92**B of radial pattern on both surfaces are present in substantially the same position, as viewed in an axial direction. The groups **92**B of radial pattern on each surface are present in an equiangular pitch around the center of the insulating board **90**. The groups **92**B of radial pattern are located immediately above the arranged circumference (circumference in which a center of each magnet **41** is arranged) of magnets **41** illustrated in FIGS. **2** and **3**. That is, the groups **92**B of radial pattern passes through a region immediately above the magnet **41** in accordance with the rotation of each coil disk. A rotational force is obtained by an electromagnetic force between an electric current flowing in the groups **92**B of radial pattern and a magnetic field generated by the magnet **41**.

FIGS. **9**A and **9**B are views explaining a coil pattern of the first coil disk **361**. FIGS. **9**A and **9**B are the same as FIGS. **8**A and **8**B, except for the symbols indicated. The coil pattern **92** of the first coil disk **361** includes two coils. In FIG. **9**A, a starting point of one coil is represented as A**1**-**1** and an ending point thereof is represented as A**1**-**2**. Further, in FIG. **9**A, a starting point of the other coil is represented as A**2**-**1** and an ending point thereof is represented as A**2**-**2**. The one coil continuously extends from the starting point A**1**-**1** via points P**11**, P**11'**, P**12'**, P**12**, P**13**, P**13'**, . . . , P**19'**, P**20'**. In this way, the one coil goes round in a clockwise direction from the starting point A**1**-**1**, as seen from the above. Similarly, the one coil goes round a total of four times in a clockwise direction and reaches a point P**50'**. And then, the one coil goes round a total of four times in a counterclockwise direction from the point P**50'** via points P**51'**, P**51**, . . . , and reaches the ending point A**1**-**2**. Similarly, the other coil continuously extends from starting point A**2**-**1** to an end point A**2**-**2**.

Connection relationship between the one coil included in the first coil disk **361** and the commutator pattern **351** of the commutator disk **35** is established such that the commutator pattern connected to the ending point A**1**-**2** is electrically connected to the other brush **83** when the commutator pattern connected to the starting point A**1**-**1** is electrically connected to one brush **83**. This connection relationship can be similarly applied to the other coil (starting point A**2**-**1**, ending point A**2**-**2**). Further, this connection relationship may be similarly applied to coils included in the other coil disks. Each coil is energized from the brush **83** through the commutator disk **35** so that the group **92**B of radial pattern of each coil disk passing over a magnetic pole surface of the magnet **41** generates a rotational torque in the same direction.

According to the present invention, the following effects can be achieved.

(1) Since the insulated radiating pattern **353** and the extended radiating pattern **355** are provided at a ring-shaped region outside of the radius R**1** on a surface of the commutator disk **35** by enlarging a diameter of the commutator disk **35** with respect to a board diameter R**1** (see, FIG. **5**) required for forming the commutator pattern **351**, an improved cooling efficiency is achieved, as compared to a case of using a related-art commutator disk (which has a board diameter of R**1** and on which the radiating pattern is not provided). Further, since an existing related-art commutator disk is used, it is possible to suppress increase in the number of parts.

(2) Since the extended radiating pattern **355** is connected to each segment of the commutator pattern **351**, a cooling efficiency of the commutator disk **35** is improved. Further, since the extended radiating pattern **355** is made of the same material as the commutator pattern **351**, heat is easily transmitted and thus cooling efficiency is improved.

(3) Since the insulated radiating pattern **354** is provided at a ring-shaped region outside of the radius R**1** on a backside of the commutator disk **35**, it is possible to effectively cool the heat between the commutator disk **35** and the first coil disk **361**. Accordingly, cooling efficiency is improved as compared to a case in which the insulated radiating pattern **354** is not provided.

(4) The surface side radiating pattern (the insulated radiating pattern **353** and the extended radiating pattern **355**) and the backside radiating pattern (the insulated radiating pattern **354**) of the commutator disk **35** are connected (coupled) to each other by the radiating through-hole **925**, respectively. Accordingly, the heat generated from the backside of the commutator disk **35** to which air (cooling air) does not flow is conducted from the insulated radiating pattern **354** to the insulated radiating pattern **353** and the extended radiating pattern **355** via the radiating through-hole **925**. As a result, heat is discharged from the surface side (against which the air (cooling air) directly strikes) of the commutator disk **35** which can be relatively easily cooled. Accordingly, a cooling efficiency of the commutator disk **35** is improved, as compared to a case in which the radiating through-hole **925** is not provided.

(5) Since each of the radiating patterns is divided into a plurality of segments, it is possible to reduce a loss (heat generation) due to an eddy current generated at the radiating patterns. Accordingly, cooling efficiency is improved.

(6) Since a cooling performance is improved as mentioned above, even in a disk motor of high output power, it is possible to withstand the heat generated thereby. Accordingly, the performance of the disk motor and the electric working machine including the same can be desirably improved.

(7) Since the commutator disk **35** and the coil disk have the same outer diameter, it is not necessary to enlarge an outer diameter of the disk motor for providing the radiating patterns, and further, manufacturing is easy.

(8) Since the commutator pattern **351** and the radiating pattern can be formed at a time by one etching process, it is possible to simplify manufacturing process and to suppress increase in cost.

While description has been made in connection with particular embodiments of the present invention, it will be obvious to those skilled in the art that various changes and modifications may be made therein without departing from the scopes of the claims. Hereinafter, modified embodiments will be described.

A modified embodiment in which only one of the insulated radiating pattern **353** and the extended radiating pattern **355** is provided is also effective. Specifically, all of the radiating patterns may be connected to each segment of the commutator pattern **351** or all of the radiating patterns may be insulated from each segment of the commutator pattern **351**.

An extending direction of the radiating pattern is not limited to a radial direction of the commutator disk **35** but may be a circumferential direction or any other direction.

The divided number of the radiating pattern is optional and not limited to the number illustrated in the above embodiment.

The backside radiating pattern (the insulated radiating pattern **354**) of the commutator disk **35** may be omitted.

It is preferable that the radiating patterns are arranged in the entire circumference to give even weight balance so that the rotor **82** can be stably rotated. The above embodiment is configured so that the same pattern appears at positions symmetrical to a rotational axis.

Instead of providing the radiating patterns on the commutator disk **35**, another board having the same radiating patterns may be placed between the commutator disk **35** and the first coil disk **361**. FIG. **10** is a front view illustrating a rotor according to such a modification and FIG. **11** is a plan view thereof. In such a modification, the commutator disk **35** has a board radius R**1** and the radiating patterns are not provided thereon, similarly to related art. A radiating disk **360** has a diameter substantially equal to the coil disk and is laminated on the first coil disk **361** with a sheet-like (insulation) adhesive layer **502** interposed therebetween. The commutator disk **35** is laminated on the radiating disk **360** with a sheet-like (insulation) adhesive layer **503** interposed therebetween. Herein, the sheet-like adhesive layer **503** has a diameter substantially equal to the commutator disk **35**. In this modification, it is not essential that the insulated radiating pattern **353** and the extended radiating pattern **355** in a surface side of the radiating disk **360** are arranged in a region outside of the radius R**1**. This is similarly applied to the backside of the radiating disk. Each of the extended radiating patterns **355** may be connected (coupled) to each segment of the commutator pattern **351** by a through-hole (not-illustrated).

Although it is not essential that the shape of the coil disk and the commutator disk is formed in a precise discoid shape, it is preferable that the shape falls within a range regarded as substantially circle, as viewed in an axial direction.

In addition, the number and arrangement pitch angle of the magnets, the winding numbers of the coil pattern (the column number of the coil pattern), the lamination number of the coil disks, the number of the pin insertion holes or through-holes and other parameters can be suitably set depending on a required performance or cost. Further, the winding numbers of the coil pattern may be different for each coil disk. When there is only one column of coil pattern, each term of "a group of partial coil pattern," "a group of inside connection pattern," "a group of radial pattern," and "a group of outside connection pattern" in the description of the above embodiment should be replaced by omitting the word "a group of" therefrom.

The electric working machine may be various electric tools which include a rotational driving part driven by a disk motor, in addition to the mower described in the above embodiment. For example, the electric working tool may be a belt sander or a rotary band saw, on which the disk motor is mounted.

What is claimed is:

1. A disk motor comprising:

a rotor including,

a commutator disk including a commutator pattern, and at least one coil disk including a coil pattern;

a stator including a magnetic flux generating part opposed to the coil pattern of the coil disk;

an electric current supply part configured to supply electric current to the coil pattern via the commutator disk and,

an output shaft configured to be rotated by a rotational force of the rotor,

wherein a radiating pattern, which is a printed-wiring including a conductive material forming a heat-dissipation path on a surface of an insulating board, is provided to an outer periphery side of the commutator pattern of the commutator disk, is provided at a position in a radial direction that faces the magnetic flux generating part, is provided to overlap the coil pattern of the coil disk in the axial direction of the output shaft, and is provided to be sandwiched between the magnetic flux generating part and the coil pattern of the coil disk.

2. The disk motor according to claim **1**, wherein the radiating pattern is provided on the commutator disk.

3. The disk motor according to claim **2**, wherein the radiating pattern is provided on both surfaces of the commutator disk, and

the radiating patterns on both surfaces are connected to each other by a thermal conductive material penetrating through the commutator disk.

4. The disk motor according to claim **2**, wherein the commutator disk and the coil disk have substantially the same outer diameter.

5. The disk motor according to claim **1**, wherein the radiating pattern is provided on at least a surface of the commutator disk that contacts with the electric current supply part.

6. The disk motor according to claim **1**, wherein the radiating pattern is divided into a plurality of segments in at least one of a radial direction and a circumferential direction.

7. The disk motor according to claim **1**, wherein the radiating pattern and the commutator pattern are made of the same material.

8. The disk motor according to claim **1**, wherein the radiating pattern includes an extended radiating pattern which extends from the commutator pattern.

9. The disk motor according to claim **8**, wherein the commutator pattern is divided into a plurality of segments, and

wherein the extended radiating pattern does not short-circuit between different segments of the commutator pattern.

10. The disk motor according to claim **1**, wherein the radiating pattern includes an insulated radiating pattern which is insulated from the commutator pattern.

11. An electric working machine comprising the disk motor according to claim **1**.

12. The disk motor according to claim **1**, wherein the conductive material forming the heat-dissipation path is separate from a current path and located on the surface of the commutator disk.

13. The disk motor according to claim **1**, wherein the radiating pattern is formed by carrying out an etching process after masking the conductive material.

14. A disk motor comprising:

an output shaft configured to be rotated by a rotational force of a rotor,

at least one coil disk, and

a magnetic flux generating part opposed to the coil pattern of the coil disk,

wherein the rotational force of the rotor is obtained by an electromagnetic force between an electric current flowing in the coil pattern and a magnetic field generated by the magnetic flux generating part,

wherein a radiating pattern, which is a printed-wiring, is provided to an outer periphery side of the output shaft, is provided at a position in a radial direction that faces the magnetic flux generating part, is provided to overlap the coil pattern of the coil disk in the axial direction of the output shaft, and is provided to be sandwiched between the magnetic flux generating part and the coil pattern of the coil disk.

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